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ABSTRACT

Calculators were used in the 1990 National Assessment of Educational Progress (NAEP) of 4th-, 8th-, and 12th-grade public school and private school students and in the Trial State Assessment of 8th-grade public school students. Before they were tested, all of the students were trained briefly in how to use the equipment. NAEP collected information about whether students understood how to use a calculator, as well as when to use one. NAEP also questioned and collected information from students, teachers, and administrators about the availability and use of calculators and computers in schools and about school policies related to their use. Presented in this fact sheet are: (1) the rationale for the use of technology in the mathematics classroom; (2) a discussion about the survey results concerning the use of calculators in the mathematics classroom; (3) a discussion about the survey results concerning the use of computers in the classroom; (4) tables of summary statistics about students' understanding of when to use a calculator, students' report on ways they use a calculator, and schools' reports on the availability of computers; and (5) questions to stimulate further discussions among teachers, principals, administrators, parents, and other interested citizens concerning the use of technology in the mathematics classroom. (JJK)

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NAEPfacts

Calculators and Computers

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NAEPfacts

Calculators and Computers

NAEPfacts are brief reports that extract the results of data on a single topic from the National Assessment of Educational Progress (NAEP); they are intended for elementary and secondary school teachers and principals. NAEPfacts describe what educators, researchers, and policymakers have to say about effective practice; provide information from NAEP about what actually takes place in schools; and conclude with questions for discussion. They are not meant to promote or prove any educational theory.

This issue of NAEPfacts is concerned with the use of calculators and computer technology in the classroom. We hope that it will promote conversations among teachers, principals, parents, and other interested parties about effective education. Readers' comments and suggestions are welcome.

E. J. Elliott

The 20th century has been marked by scientific advances that have had a profound effect on American enterprises such as manufacturing, business management, transportation, and communications. We entered the century with a horse-drawn carriage; we leave it with spacecraft probing the universe. We entered the century with pencil and paper; we leave it with computers able to figure thousands of times faster than the human brain.

Technology has revolutionized the education needs of the workforce as it has revolutionized the workplace. As a result, schools that use only pencil and paper to teach mathematics, for example, are as out of step with the times as those that would use a horse-drawn carriage to teach auto mechanics.

Yet, there is little evidence that technology is used to full advantage in the American schoolroom. In fact, teachers report that 47 percent of 4th-graders and 22 percent of 8th-graders were *never* asked to use a calculator in mathematics class. This was a finding of the 1990 NAEP assessment in mathematics.

Technology in the Mathematics Classroom

The National Council of Teachers of Mathematics (NCTM), a professional association of classroom teachers, supervisors, educational researchers, teacher educators, and university faculty, states that the very nature of the mathematics

curriculum must be changed to meet the needs of the next century. Mathematics problems and the methods used for solving them have changed with technological advances.

The understanding and competent use of technological tools are indispensable to U.S. students, all of whom will have a role in the nation's progress in the 21st century. Thus, NCTM recommends expanded use of computers and calculators in schools.

In its publication, *Curriculum and Evaluation Standards for School Mathematics*, NCTM recommends that

- Appropriate calculators be available to all students at all times;
- Every classroom have a computer for demonstration purposes;
- Every student have access to a computer for individual and group work; and
- All students learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems.

Further, students' understanding of mathematics should equip them to know *when* and *how* to use the various technologies for problem solving. "Students should be able to decide when they need to calculate and whether they require an exact or approximate answer," NCTM says.

Use of Calculators in the Classroom

A calculator component has been a part of the NAEP mathematics assessment since 1982; albeit a small part. To determine how and to what extent calculators actually are used in classroom practice, the component was expanded in the 1990 assessment.

Calculators were used in the 1990 national assessment of 4th-, 8th-, and 12th-grade public and private school students and in the Trial State Assessment of 8th-grade public school students. Fourth-graders had the use of four-function calculators and 8th- and 12th-graders the use of scientific calculators for portions of the assessment. Before they were tested, all of the students were trained briefly in how to use the equipment.

NAEP collected information about whether students understood how to use a calculator, as well as when to use one (see tables 1 and 2). NAEP also questioned and collected information from students, teachers, and administrators about the availability and use of calculators and computers in schools and about school policies related to their use.

NAEP results show that NCTM's recommendations have not been implemented. According to their teachers, only 3 percent of 4th-graders and 19 percent of 8th-graders were permitted free and open use of calculators; only 2 percent of 4th-graders and 34 percent of 8th-graders were permitted to use calculators when taking tests. As 1, as indicated earlier, teachers reported that 47 percent of 4th-graders and 22 percent of 8th-graders were never asked to use a calculator in mathematics class.

Fourth-grade teachers tended to use calculators somewhat more frequently in their high-ability classes; 8th-grade teachers said they used them least frequently with their low-ability classes. Although there are some exceptions, more-proficient students appear to have more opportunities to use calculators than their less-proficient peers.

Use of Computers in the Classroom

Computers can be used in a variety of ways in the mathematics classroom. Teachers can take full advantage of this technology by using computers to teach such things as statistics, graphs, spreadsheets, and proportions and to encourage students to undertake extended investigations of mathematical ideas requiring higher-order thinking skills and logic.

Computers give students an opportunity to use "hands-on" techniques in problem solving. Perhaps more important, they help students develop an understanding of the processes and reasoning that are the heart of mathematical problem solving. Because computers can be used in ways that parallel the application of mathematics in the real world of business and industry, computer technology in the classroom enhances practicality and students' interest.

Computers are expensive and finding the resources to make them available for the use of students can be a problem. NAEP asked school administrators and teachers about the availability of computers in mathematics classrooms (see table 3).

School administrators and teachers appear to agree that more 4th-grade than 8th-grade mathematics classrooms have computers. Teachers reported that, at grade 4, about one-third of students had at least one computer in their classrooms. Teachers and administrators reported that, at grade 8 and again at grade 12, about one-fifth of students had at least one computer in their mathematics classrooms.

Many schools have computer laboratories, and school administrators reported that—across the grades—more than half of students were in schools where computers were available for classroom use when needed. Fifty-six percent of students in grade 4, 61 percent of students in grade 8, and 79 percent in grade 12 were in schools with computer laboratories.

If computers are to have an impact on mathematics instruction and achievement, students must have opportunities to use the equipment. NAEP, therefore, asked teachers and administrators about student use. Despite the availability of computers, teacher reports indicated that access to them was more limited.

Teachers and administrators reported that computer access was difficult for about half of the students at grades 4 and 8. Teachers and students agreed that school use of computers was greater at grade 4 than at grade 8, but usage in general was quite limited. A positive overall relationship was seen to exist between the availability of computers and average mathematics proficiency at grade 4; this relationship tended to hold across ability groupings at that grade level. At grade 8, however, there appeared to be no relationship between the availability of computers and mathematics performance.

Table 1.—Students' understanding of when to use a calculator

	High Group [*]		Other Group ^{**}	
	Percent of students	Average proficiency	Percent of students	Average proficiency
Grade 4	57 (0.7)	221 (0.7)	43 (0.7)	209 (0.9)
Grade 8	44 (0.9)	275 (1.3)	56 (0.9)	258 (1.1)
Grade 12	30 (0.8)	310 (1.3)	70 (0.8)	289 (1.1)

NOTE: The standard errors of the estimated percentages and proficiencies appear in parentheses. It can be said with 95 percent certainty that for each population of interest, the value for the whole population is within plus or minus two standard errors of the estimate for the sample.

SOURCE: *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation and the Trial State Assessment of the States.*

^{*}High Group—Students who used the calculator appropriately (i.e., used it for the calculator-active items and did not use it for the calculator-inactive items) at least 85 percent of the time and indicated that they had used the calculator for at least half of the calculator-active items they were presented.

^{**}Other Group—Students who did not use the calculator appropriately at least 85 percent of the time or indicated that they had used a calculator for less than half of the calculator-active items they were given.

Table 2.—Students' reports on ways they use a calculator

For mathematics class, how often do you use a calculator to do each of the following?						
	Almost always		Sometimes		Never	
	Percent of students	Average proficiency	Percent of students	Average proficiency	Percent of students	Average proficiency
Work problems in class						
Grade 8	46 (0.9)	257 (1.1)	30 (1.1)	271 (1.6)	24 (1.3)	275 (1.2)
Grade 12—All students	42 (1.0)	301 (1.1)	32 (0.8)	298 (1.4)	27 (1.0)	285 (1.6)
Grade 12—Taking math	53 (1.2)	306 (1.3)	33 (1.0)	308 (1.5)	14 (0.9)	299 (3.0)
Do problems at home						
Grade 8	30 (1.0)	264 (1.2)	52 (0.8)	266 (1.3)	19 (0.7)	266 (1.3)
Grade 12—All students	38 (0.9)	305 (1.2)	38 (0.7)	295 (1.4)	24 (0.8)	283 (1.5)
Grade 12—Taking math	46 (1.0)	311 (1.3)	41 (1.0)	303 (1.5)	13 (0.6)	294 (2.5)
Take tests or quizzes						
Grade 8	25 (0.9)	257 (1.6)	43 (1.2)	261 (1.5)	32 (1.3)	277 (1.2)
Grade 12—All students	34 (0.9)	303 (1.2)	34 (0.9)	298 (1.4)	32 (1.1)	277 (1.2)
Grade 12—Taking math	43 (1.3)	309 (1.3)	38 (1.2)	304 (1.6)	19 (1.1)	300 (2.7)

NOTE: The standard errors of the estimated percentages and proficiencies appear in parentheses. It can be said with 95 percent certainty that for each population of interest, the value for the whole population is within plus or minus two standard errors of the estimate for the sample.

SOURCE: *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation and the Trial State Assessment of the States.*

Table 3.—Schools' reports on the availability of computers

	Yes, computers available all the time in mathematics classroom	Yes, computers grouped in a laboratory available to mathematics classes	Yes, computers available to bring to classroom when needed
	Percent of students	Percent of students	Percent of students
Grade 4	22 (2.7)	56 (2.9)	53 (3.1)
Grade 8	10 (2.6)	61 (4.4)	57 (3.5)
Grade 12	10 (2.6)	79 (3.8)	64 (3.7)

NOTE: The standard errors of the estimated percentages and proficiencies appear in parentheses. It can be said with 95 percent certainty that for each population of interest, the value for the whole population is within plus or minus two standard errors of the estimate for the sample.

SOURCE: *The State of Mathematics Achievement: NAEP's 1990 Assessment of the Nation and the Trial State Assessment of the States.*

Questions for Discussion

NAEP data reveal minimal use of computers and calculators in mathematics instruction. In many cases, technology is not widely available, accessible, or used to advance students' mathematical thinking. The following questions are posed to stimulate discussion among teachers, principals, administrators, parents, and other interested citizens about the use of calculators and computers in the classroom:

1. What are the pros and cons of allowing students to use calculators only after they have proven their ability to compute with pencil and paper? Does this policy worsen the performance gap between higher- and lower-performing students?
2. How can calculators be used to help students develop a broader view of mathematics problem solving?
3. Can students be taught estimation techniques that will help them recognize whether computer or calculator results are reasonable? If so, how?
4. How can computers be used to help students develop the mathematical reasoning and problem-solving concepts required in the real world?
5. How can computers be used in mathematics programs to simulate problem-solving situations and applications?
6. Does electronic mail have a role in mathematics programs?

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